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Effect of Inorganic and Organic Fertilizers on Growth and Yield of Two Industrial Potato Varieties (Asterix and Courage) in Bangladesh

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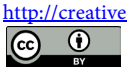

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Abstract

Potato is one of the most important vegetable crops, which contributes more than half of the total vegetable production in Bangladesh. Four field experiments were conducted in two different locations in Bangladesh to develop integrated nutrient management practices to produce quality potato seed in industrial processing varieties Asterix and Courage. For the inorganic trial, Factorial Randomized Complete Block Design (RCBD) including 2 potato varieties, 5 treatments with 4 replications, and in the organic fertilizer trial, Factorial RCBD including 2 potato varieties, 6 treatments with 4 replications were used. In the inorganic fertilizer trail, the highest yield was obtained in the variety Asterix due to Nitrogen, Phosphorus, Potassium, and Sulfur (NPKS) plus Magnesium treated plot in Domar BADC farm and due to NPKS plus Boron, Zinc, and Magnesium treated plots in Kashimpur Farm. In the case of variety Courage, the highest yield was found in the treatment of NPKS plus Zinc in Domar BADC farm while in Kashimpur farm, NPKS plus Mg treated plots had the highest yield of potato variety-Courage. In the organic fertilizer trail, the highest tuber yield per hill was obtained by applying the government-approved commercial brand Northern organic fertilizer in variety Asterix and by organic fertilizer brand Chook Chook in variety Courage. Parameters such as days to tuber initiation, number of stems per hill, plant height, and number of tubers per hill were found statistically different among the treatments and between the two varieties. Treatments namely Northern organic fertilizer and Cowdung combined with mustard oil cake performed better considering standard grade tuber yield (grade A and B) compared to

other treatments. Hence, the combination of NPKS MgZn and either Northern organic or Chook Chook or Cowdung plus mustard oil cake could be used to grow the varieties Asterix and Courage.

Keywords

Potato Yield, Tuber, Cowdung, Nutrients, Grade-Wise

1. Introduction

Potato is a global crop and ranked fourth as a major food crop in the world after maize, rice, and wheat, concerning yield. It is the world's number one non-grain food commodity which is grown and consumed in more countries than any other crop with production reaching a record 376 million Metric Ton (MMT) in 2013 [1]. Bangladesh is now the 7th highest potato-producing country (8.6 MMT) among the 158 potato-producing countries in the world [2]. However, the country is positioned behind the 67 countries of the world in respect of yield [1]. The average yield of potatoes in Bangladesh is only 14 - 15 MT/ha which is much lower than the Netherlands (41.3 MT/ha), Ukraine (44.0 MT/ha), USA, and other countries [3]. The major cause of this low yield of potatoes in Bangladesh is mainly due to the use of poor-quality seed potatoes.

In Bangladesh, the population is increasing at an alarming rate at 1.2% and the present rate of decline of agricultural land is 0.14% [4]. So, the scope of horizontal expansion of land under potato cultivation in the country is limited. Thus, the vertical expansion (yield/unit area) is the only solution to feed the country's increasing population beyond 15 cores. Moreover, in Bangladesh around eight processing industries have been developed to produce potato chips, French fries, etc. So, the demand for table potatoes, as well as industrial potatoes in the country is increasing gradually. Nitrogen is the first limiting nutrient for potato yield [5]. The higher dose of nitrogen increases the yield of tubers but decreases the dry matter content. Therefore, the use of both organic and inorganic fertilizers in appropriate proportions assumes special significance as complementary to each other in crop production.

The farmers of Bangladesh use different inorganic fertilizer doses in different parts of the country. As a result, potato yield comes down for the use of inorganic fertilizer. Some of the areas have been applying excessively inorganic fertilizer which may simply be called fertilizer. At present, the farmers of Bangladesh mainly use inorganic fertilizers for potato cultivation. Most soils have less than 1.5% OM and some soils have even less than 1% OM [6]. Integrated use of organic matter and chemical fertilizer is increasingly realized to maintain soil health status and to increase potato production. On the other hand, organic agriculture is giving importance to some countries. Several organic fertilizers have been approved by the People's Republic of Bangladesh as well as adding organic

matter to produce potatoes is historical practice by the farmers.

Although Bangladesh is the 4th largest potato producer in Asia, potato processing is still at a very slow pace due to the non-availability of suitable potato varieties. All the released varieties in the country except Asterix, Courage, Lady Rosetta, and Meridian are meant for table purposes only. The table potato varieties generally consist of low dry matter (15% - 18%) and high reducing sugar content which are considered undesirable traits for industrial processing. The concept of integrated use of organic matter and chemical fertilizers is increasingly realized in maintaining soil fertility and crop productivity. In Bangladesh, fertilizer doses are used as per the recommendation made by the Tuber Crops Research Center (TCRC), Bangladesh Agricultural Research Institute (BARI). These doses were suggested about 10 years earlier based on table potato varieties. So, such recommendations (both for macro and micronutrients) need to be revised or cross-checked in the present situation, considering both table and processing purposes. In addition, a good number of organic fertilizers are available in the market whose potentialities have not been properly documented. Under the above scenario, the present research works have been designed to optimize the doses of inorganic fertilizer for both macro and micronutrients and to search for suitable organic fertilizer to produce industrially processing seed potato varieties-Asterix and Courage.

2. Methodology

The experiments were conducted at the Domar Foundation Seed Potato Production Farm, Nilphamari, and Farmer's Field, Kashimpur, Gazipur, Bangladesh during potato growing seasons (November to March) in 2010-2011. The soil was characterized as highly acidic (pH 5.4) at Kashimpur, Gazipur, and slightly acidic (pH 6.04) at Domar Seed Potato Farm (Table 1). The foundation class of seeds of two popular industrial potato varieties namely Asterix & Courage were used in the study. For the inorganic trial, Factorial Randomized Complete Block Design (RCBD) in which 2 potato varieties, 5 treatments with 4 replications, and Factorial RCBD where 2 potato varieties, 6 treatments with 4 replications under the organic trial were used. The plot size was 2 m × 3 m each.

Table 1. Initial soil status of two experimental fields.

Location	Soil PH	Organic matter (%)	Total Nitrogen (%)	Calcium meq/100 g soil	Magnesium meq/100g soil	Potassium meq/100g soil	Phosphorus ug/g of soil
Kashimpur, Gazipur	5.0 highly acidic	1.14 low	0.057 very low	2.54 low	0.60 low	0.20 optimum	43.1 very high
Domar Seed Farm	6.04 slightly acidic	1.10 low	0.06 very low	- -	0.56 low	0.16 medium-low	19.12 very high

Source: Soil tested by Soil Resource Development Institute, Dhaka, Bangladesh.

Treatments (Inorganic fertilizer trial):

Treatment 1 = Urea@350 kg/ha + TSP@220 kg/ha + MP@265 kg/ha

Treatment 2 = Urea@350 kg/ha + TSP@220 kg/ha + MP@265 kg/ha + Borax @12.5 kg/ha + Gyp@83kg/ha

Treatment 3 = Urea@350 kg/ha + TSP@220 kg/ha + MP@265 kg/ha + Zinc sulphate@ 14.60 kg/ha

Treatment 4 = Urea@350 kg/ha + TSP@220 kg/ha + MP@265 kg/ha + Magnesium sulphate @ 83 kg/ha

Treatment 5 = Urea@350 kg/ha + TSP@220 kg/ha + MP@265 kg/ha + Zinc sulphate@ 14.60 kg/ha + Magnesium sulphate @83kg/ha

Treatments (organic fertilizer trial):

T_1 = No Organic Fertilizer

T_2 = Chook Chook @ 60 kg/ha

T_3 = Onnopurna @ 125 kg/ha

T_4 = Northern @ 125 kg/ha

T_5 = Micro-Soil @ 0.20 l/ha

T_6 = Cow Dung @1250 kg/ha plus Mustard Oil Cake @62.5 kg/ha

The experimental field was plowed mechanically and leveled properly to have a good tilth. The inorganic fertilizer dose/ha was recommended by TCRC. Half of the Urea and Murate of Potash (MoP) and the whole quantity of Triple Super Phosphate (TSP) and other micronutrients were applied to the soil of the growing potato crops as a top dressing after 35 days of planting of seed potato. In the case of the organic fertilizer trial, a whole amount of different organic fertilizers was applied to the soil based on the treatment combination at the time of the final plowing of the experimental field. The foundation seed potato was collected from Bangladesh Agricultural Development Corporation (BADC) and seed potatoes were kept in a defused light in the storeroom for 72 hours for pre-sprouting. Then, the grade A (28 - 40 mm) seed tubers were cut into two pieces and grade B (41 - 55 mm) seed tubers were cut into 2 - 3 pieces and kept the cut tubers to cool shady place for 48 - 72 hours for healing or suberization. Then, the seed potatoes were planted in the experimental potato field. Row-to-row distance of 60 cm and tuber-to-tuber distance of 20 cm were maintained. Mulching and weeding were carried out after 20 days of planting. Just after mulching, the first irrigation was carried out. Another eight times irrigation was given in Domar potato seed production farm and four times irrigation was given in farmer's field at Kashimpur. After 35 days of planting, the insecticide Dursburn (Chemical name: Chloropyriphos) was applied in all the plots @ 3.75 liter/ha to control cutworms. Three sprays of systemic fungicide Acrobat MZ (Chemical name: Dimethomorph and Mancozeb) were applied at 10-day intervals to control fungal diseases. To control aphid, which is the vector for spreading virus diseases, 3 sprays of Asataf (75% SP formulation of Acephate) and 3 sprays of Admire (Chemical name: Imidacloprid) were applied at 7-day intervals. Data was taken on days to tuberization, the number of stems/hills at 60 days after sowing (DAS), plant height (60 DAS), the number of tuber/hill

and tuber weight/hill at harvest, etc. The potato plants were uprooted as branches of the plant did not leave in the field. After haulm pulling the potato was kept on the field for 10 days for hardening of the skin. The potato was harvested and taken the potato to a cool shady place where sorting, grading, and weighting were done. The experimental data was analyzed using Statistix 10.0 software.

3. Results

3.1. Inorganic Fertilizers Trial

3.1.1. Days to Tuberization, Number of Stem/Hills, Plant Height, Number of Tuber/Hills

The results revealed that the highest days to tuberization (36 days) were observed in a variety of Asterix which was statistically like other treatments in the Domar Farm (Table 2). On the other hand, only 26.50 days were required for tuberization in the treatment T2 of variety Courage which was statistically like other treatment of variety Courage. Results indicate that the minimum number of days required to tuberization in variety Courage compared to variety Asterix and there was around 10 days difference between the two varieties. Similar trends of results were obtained in the Kashimpur farms where a significant difference was observed between the two varieties as well (Table 2).

In Domar farm, the number of stems/hills ranged from 3.25 to 4.50 (Table 2) where the maximum number was obtained in T4 in the case of variety Asterix which was statistically like T1 in variety Courage, and the minimum number of stem/hills (3.25) was found in T3 of variety Courage. There was no difference found between the variety Asterix and Courage in Kashimpur farm (Table 2).

Table 2. Effect of five inorganic fertilizer treatments on the days to tuberization and number of stems per hill of two industrial potato varieties grown at two different locations.

Treatments	Days to tuberization				Number of stems per hill			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
T1 (NPKS)	36.25a	26.75b	36.25a	26.75b	4.00abc	4.50a	3.42a	3.92a
T2 (NPKS + B)	36.75a	26.50b	36.75a	26.50b	3.50bc	4.00abc	3.50a	4.50a
T3 (NPKS + Zn)	36.25a	27.00b	36.25a	27.00b	3.50bc	3.25e	3,67a	3.58a
T4 (NPKS + Mg)	36.75a	26.75b	36.75a	26.75b	4.50a	4.25ab	3.84a	3.67a
T5 (NPKS + BZnMg)	36.75a	27.00b	36.75a	27.00b	3.75abc	4.00abc	3.50a	4.50a
LSD ($p < 0.05$)	1.051		1.057		0.779		1.095	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

Table 3. Effect of five inorganic fertilizer treatments on the plant height (cm) and number of tubers per hill of two industrial potato varieties grown at two different locations.

Treatments	Plant height (cm)				Number of tubers per hill			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
T1 (NPKS)	52.92a	56.42a	50.75a	36.34d	11.75a	8.75bc	8.75a	7.50bc
T2 (NPKS + B)	54.00a	53.08a	49.09b	36.25de	11.00abc	9.00bc	7.08c	7.50bc
T3 (NPKS + Zn)	60.16a	52.50a	48.68b	36.42d	11.25ab	9.75abc	7.50bc	7.75bc
T4 (NPKS + Mg)	58.00a	57.58a	50.92a	37.50c	11.25ab	8.50c	7.67bc	7.59bc
T5 (NPKS + BZnMg)	56.17a	56.50a	51.42a	35.25e	12.25a	9.00bc	8.17ab	7.59bc
LSD ($p < 0.05$)	7.034		1.004		2.262		0.715	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

Asterix and Courage in Domar farm (Table 3). In Kashimpur farm, the highest plant height (51.42 cm) was found in the treatment T5 which was statistically like T1 and T4 of variety Asterix. On the other hand, there was lower plant height in all the treatments of variety Courage and the least height (35.25 cm) was observed in treatment T5 (Table 3).

The maximum number of tubers per hill (12.25) was observed in the treatment T5 which was statistically like T1 of variety Asterix and the lowest number of tubers per hill (8.50) was found in the treatment T4 of Courage in the Domar farm (Table 3). In Kashimpur farm, the higher number of tubers per hill was 8.75 in T1, and the lowest was observed in T2 of variety Asterix. No difference was found among treatments of variety Courage (Table 3).

3.1.2. Tuber Weight/Hills and Grade-Wise Yield/Plot

In Domar farm, the highest tuber weight per hill (476.66 g) was obtained in the treatment T4 of variety Asterix, and the lowest of 299.58 g/hill was found in the treatment T2 of variety Courage, which was statistically like the treatments T1, T4 and T5 of variety Courage (Table 4). On the other hand, there was a statistically significant difference observed among treatments of both varieties Asterix and Courage. The maximum tuber weight of 385.00 g/hill was found in the treatment T5 of Asterix, followed by T4 of Courage (316.92 g), T1 of Asterix (297.5 g), and the minimum tuber weight of 203.34 g/hill was found in treatment T1 of variety Courage (Table 4).

In Domar farm (Figure 1), the highest A grade (28 - 40 mm) tuber was found in T3; followed by T4 of the variety-Asterix, and in T1 (NPKS) of the variety Courage; followed by T4 and T2 of Courage. The highest B grade (41 - 55 mm) tuber was found in T5 of the Asterix variety; followed by T3 and T2. In the case of Courage, T4 had the maximum B-graded seed followed by T3 and T5. The

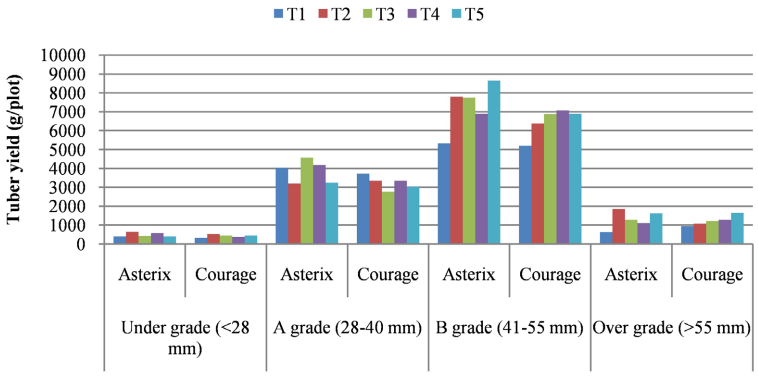

Figure 1. Grade-wise yield (g/plot) of two processing varieties under inorganic fertilizer treatment at Domar farm. Here, T1: NPKS; T2: NPKS + B; T3: NPKS + Zn; T4: NPKS + Mg; T5: NPKS + BZnMg.

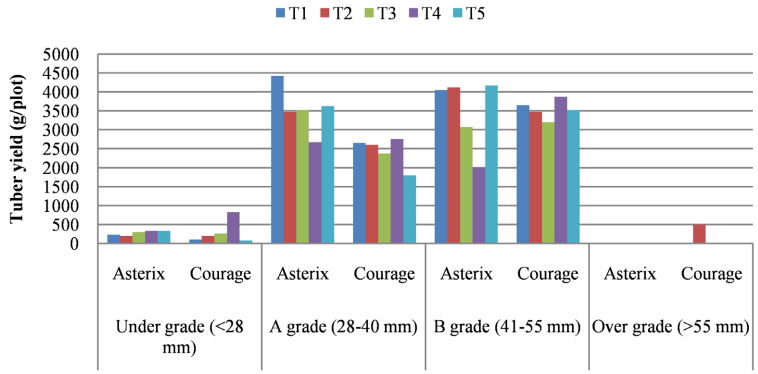

Figure 2. Grade-wise yield (g/plot) of two processing varieties under inorganic fertilizer treatment at Kashimpur farm. Here, T1: NPKS; T2: NPKS + B; T3: NPKS + Zn; T4: NPKS + Mg; T5: NPKS + BZnMg.

oversize (>55 mm) tuber was obtained in T2 of variety Asterix and T5 of variety Courage. At Kashimpur Farmer's Field, (**Figure 2**), the highest A-grade seed tuber was found in T1 (NPKS) of Asterix & lowest in T5 of Courage; the highest B-grade (41 - 55 mm) tuber was found in T5 of Asterix & T4 of Courage; oversize (>55 mm) tuber was found only in T2 of Courage variety.

Table 4. Effect of five inorganic fertilizer treatments on the tuber weight (g)/hill of two industrial potato varieties grown at two different locations.

Treatments	Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage
T1 (NPKS)	382.33bc	314.16c	297.50c	203.34j
T2 (NPKS + B)	435.00ab	299.58c	260.84g	275.84f
T3 (NPKS + Zn)	436.66ab	382.08bc	284.17d	255.00h
T4 (NPKS + Mg)	476.66a	327.50c	279.58e	316.92b
T5 (NPKS + BZnMg)	458.33ab	334.16c	385.00a	239.58i
LSD ($p < 0.05$)	79.45		4.22	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

3.2. Organic Fertilizers trial

3.2.1. Days to Tuberization, Number of Stem/Hills, Plant Height, Number of Tuber/Hills

In Domar farm (Table 5), there was a significant difference between treatments of variety Asterix and among treatments of variety Courage but early tuberization was found in variety Courage compared to variety Asterix. In the Kashimpur farmer's field, there were similar trends of days to tuberization observed in the case of both varieties.

In Domar farm, the highest number of stems of 3.25 per hill was found in T4 of both varieties Asterix and Courage which was statistically similar to T3 of variety Courage but statistically significant compared to other treatments (Table 5). The lowest number of stems per hill (2.50) was found in the control (T1) of variety Courage. In Kashimpur, there was no statistical difference observed among treatments of both varieties Asterix and Courage (Table 5).

Table 5. Effect of six inorganic fertilizer treatments on the days to tuberization and number of stems per hill of two industrial potato varieties grown at two different locations.

Treatments	Days to tuberization				Number of stems per hill			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
T1 (No)	35.50a	26.50b	31.00a	28.00b	2.75ab	2.50b	2.75a	2.67a
T2 (CC)	35.50a	26.25b	31.00a	28.00b	3.00ab	3.00ab	2.67a	2.75a
T3 (OP)	36.00a	26.00b	30.75a	27.75b	3.00ab	3.25a	2.92a	2.33a
T4 (NOF)	36.00a	26.75b	30.50a	27.25b	3.25a	3.25a	2.50a	2.67a
T5 (MS)	35.75a	26.25b	30.75a	27.50b	3.00ab	3.00ab	2.92a	2.75a
T6 (CMOC)	35.75a	26.50b	31.00a	28.00b	3.00ab	3.00ab	2.67a	2.75a
LSD ($p < 0.05$)	0.832		1.098		0.605		0.968	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

Table 6. Effect of six organic fertilizer treatments on the plant height (cm) and number of tubers per hill of two industrial potato varieties grown at two different locations.

Treatments	Plant height (cm)				Number of tubers per hil			
	Domar		Kashimpur		Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage	Asterix	Courage	Asterix	Courage
T1 (No)	32.83c	43.66ab	28.92a	24.50a	6.50ab	5.50b	5.58ab	5.92ab
T2 (CC)	40.83ab	40.33ab	29.75a	24.08a	7.00a	7.25a	5.34ab	3.75c
T3 (OP)	41.66ab	37.16bc	29.08a	24.00a	7.50a	7.25a	4.58bc	5.16abc
T4 (NOF)	43.58ab	44.16ab	29.58a	24.09a	7.50a	7.50a	5.25abc	6.33a
T5 (MS)	40.92ab	38.33bc	30.83a	25.00a	7.25a	7.00a	5.33ab	5.58ab
T6 (CMOC)	44.58ab	46.91a	29.42a	25.33a	7.75a	6.50ab	5.67ab	4.75abc
LSD ($p < 0.05$)	6.377		25.00		1.136		1.382	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

The maximum number of tuber per hill (7.75) was observed in the treatment of T6 of Asterix which was statistically similar to T2, T3, T4, and T5 of both varieties-Asterix and Courage in Domar farm (Table 6). The minimum number of tuber per hill was found in the control treatment of potato variety Courage. On the other hand, a higher number of tuber per hill of 6.33 was found in treatment T4 of Courage in the Kashimpur farm, which was statistically highly significant. The lowest number of tuber per hill of 3.75 was obtained in the treatment of T2 of Courage. There were no trends observed regarding the number of tubers per hill in the case of variety Asterix in the Kashimpur farm (Table 6).

3.2.2. Tuber Weight (g)/Hills and Grade-Wise Yield (g)/Plot

The maximum tuber weight (214.00 g) was found in the treatment of T4 of Asterixin the Domar Farm which was statistically different from other treatments, followed by 206.25 g in the treatment of T6 of Asterix (Table 7). The lowest tuber weight of 140.83 g was found in the treatment of T3 of Asterix which was statistically similar to the same treatment of Courage and control of Asterix.

In Kashimpur, the maximum tuber weight of 122.92g was obtained in Cowdung and mustard oil cake-treated plants (T6) which was statistically highly significant among treatments (Table 7). The second highest tuber weight of 122.92 g was also obtained from treatment T5 of variety Asterix which was statistically similar to the control treatment of Asterix. The ranges of tuber weight per hill were 70.84 to 93.33 g among treatments of variety Courage which was much lower than variety Asterix where ranges were 84.167 to 122.92 g among treatments.

In Domar Farm (Figure 3), the highest A-grade (28 - 40 mm) and B-graded tuber yield was found in T4 of Asterix and lowest A-graded in T1 of Courage and B-graded in T4 of Asterix. There was no over-graded seed in any of the treatments of both varieties. On the other hand, in Kashimpur Farmer's Field (Figure 4), the highest under-size tuber yield was obtained in T3 of variety Asterix and the lowest under-size tuber yield was obtained in T4 of variety Courage. The highest A-grade tuber yield was found in T2 of variety Asterix and the lowest

Table 7. Effect of six organic fertilizer treatments on the tuber weight (g)/hill of two industrial potato varieties grown at two different locations.

Treatments	Domar		Kashimpur	
	Asterix	Courage	Asterix	Courage
T1 (No organic fertilizer)	147.50d	167.08cd	108.33b	71.67j
T2 (CC)	191.16abc	198.33abc	84.17g	79.17h
T3 (OP)	140.83d	145.75d	100.42c	87.50f
T4 (NOF)	214.00a	190.00abc	95.84d	76.67i
T5 (MS)	168.75cd	170.00cd	108.33b	70.84j
T6 (CMOC)	206.25ab	173.25cd	122.92a	93.33e
LSD ($p < 0.05$)	31.82		1.582	

*Values with the same letters within rows and columns are not significantly ($p < 0.05$) different.

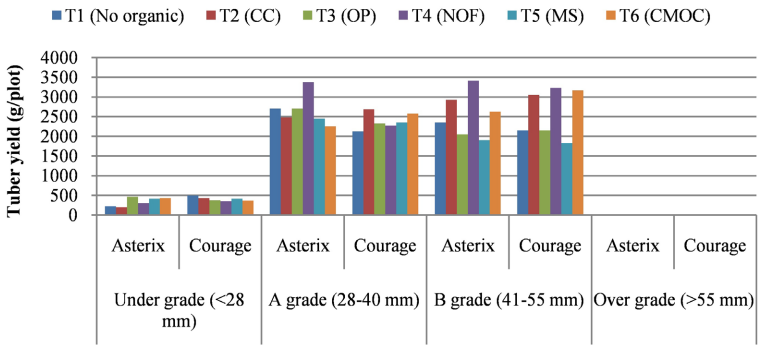

Figure 3. Grade-wise yield (g/plot) of two processing varieties under organic fertilizer treatment at Domar farm. Here, T1 = No Organic Fertilizer; T2 = Chook Chook @ 60 kg/ha; T3 = Onnopurna @ 125 kg/ha; T4 = Northern @ 125 kg/ha; T5 = Micro-Soil @ 0.20 l/ha; T6 = Cow Dung @1250 kg/ha plus Mustard Oil Cake @62.5 kg/ha.

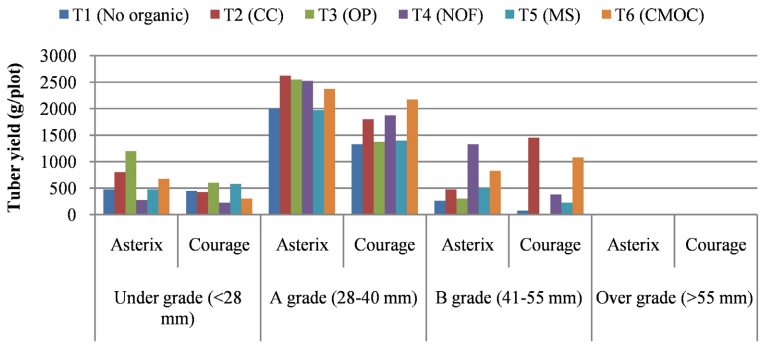

Figure 4. Grade-wise yield (g/plot) of two processing varieties under organic fertilizer treatment at Kashimpur farm. Here, T1 = No Organic Fertilizer; T2 = Chook Chook @ 60 kg/ha; T3 = Onnopurna @ 125 kg/ha; T4 = Northern @ 125 kg/ha; T5 = Micro-Soil @ 0.20 l/ha; T6 = Cow Dung @1250 kg/ha plus Mustard Oil Cake @62.5 kg/ha.

A-grade tuber yield was observed in T1 of variety Courage. The highest B-grade tuber yield was obtained in T2 of variety Courage. In variety Courage, there was no B-grade tuber found in T3. In addition, no oversized tuber yield (>55 mm) was found in both Asterix and Courage Variety at Kashimpur Farmer's Field.

4. Discussion

In the case of the inorganic fertilizer trial, the highest tuber weight per hill was obtained in the variety Asterix in which micronutrients were applied along with macronutrients. In the case of variety Courage, the highest tuber weight/hill was found in T3 in which zinc was added with macronutrient contents. Both the varieties did not show any significant response to the nutrient supplements in days to tuberization, plant height, and the number of tubers per hill. In the case of tuber grade, the highest seed tuber yield was obtained by the application of three micronutrients (BZnMg) in combination with NPKS.

Potato requires an adequate supply of different plant nutrients such as N, P, and K to ensure rapid and steady growth and tuber development. The higher

dose of nitrogen increases the yield of tubers but reduces the dry matter content in potatoes. In our study, nitrogen was applied in the form of urea fertilizer @350kg/ha (N@160 kg/ha), phosphorus as TSP @220 kg/ha (P@100 kg/ha), potassium @265 kg/ha (K @132.5 kg/ha) and better growth and yield parameters in the present study. Similarly, it was mentioned that potatoes planted responded significantly to different NPK rates, where 125 kg·N, 100kg P, and 125kg K per ha had the highest number of tubers and tuber weight per hill and total yield of potato [7]. The yields of potatoes were found to be increased by 32% - 93% due to the combination of phosphorus and potassium with nitrogen fertilizer [8].

Potato tuber yield increased significantly due to foliar and soil application of micro-nutrients. Several workers stated that the application of micronutrients in addition to essential major elements can play a good role in increasing the yield of potato tubers [9]. In our study, micronutrient elements namely gypsum @83 kg/ha, zinc sulfate @14.60 kg/ha, borax @12.5 kg/ha, and magnesium sulfate @83 kg/ha were applied to the soil based on the different combinations which resulted in the enhancement of growth and yield parameter compared to micronutrient deficient treatment. Similarly, the tuber yield of 26.76 MT/ha and 26.47 MT/ha were obtained due to the application of Cowdung@15 MT/ha plus Borax@10 kg and cowdung @15 MT/ha plus gypsum@90 kg/ha, respectively [10]. The treatment receiving Zn, B, S, and Mg together had the highest tuber yield (30.90 MT/ha) and a yield increment of 21.65% compared to the control [11]. Therefore, micronutrient content also plays an important role along with NPK fertilizer to have higher production of potatoes.

In the case of the organic fertilizer trail, the result of the present study revealed that days to tuberization, number of stems/hill, plant height, and number of tuber/hill were observed statistically similar among the treatments but differed between the two varieties. The highest tuber yield/hill of variety Courage was obtained by applying Chook Chook organic fertilizer. Chook Chook-150 is a government-approved organic fertilizer that consists of 23.62% organic matter, 4.5% N, 10.22% P (P_2O_5), 7.27% K (K_2O), 9.00% Ca in addition to other micronutrients such as 1.72% S, 1.3% Mg, 1.5% Zn, 0.18% Mn, 0.09% B, 0.006% Cu [12]. This organic fertilizer (ChookChook-150) was found to increase the number of stems per hill, number of tubers per plant, tuber weight per plant, and tuber yield (MT/ha) of potatoes compared to farmers' plots; in addition, all of the TPS (true potato seed) varieties were responded very well to ChookChook-150 organic fertilizer in terms of plant growth and tuber yield compared to non-Chook Chook plots [13]. This organic fertilizer had a significant effect on grades of tuber and the highest tuber yield (19.80 MT/ha) was found due to the application of Chook Chook organic manure [14]. ChookChook-150 had a significant positive effect on plant growth and increase of yield of both potato (variety Asterix) and groundnut by 28.88% and 22.02%, respectively [15].

In Domar farm, maximum tuber yield/hill, A-graded, and B-graded tubers of variety Asterix were obtained due to application of Northern organic fertilizer. Nutrient elements of Northern organic fertilizer consist of N (4%), P_2O_5 (1.15%),

K_2O (1.5%), S (1%), Ca (2.5%), Mg (0.75%), Fe (0.05%), Mn (170 ppm), Zn (150 ppm), Cu (24 ppm), B (1.60 ppm), Mo (3.0 ppm), and OM (10%). The maximum gross and marketable yields of tubers of potato cv. Diamant (23.68 & 21.28 MT/ha), respectively were obtained due to the application of Northern Organic Fertilizer (http://www.northernfertilizer.org). Application of Northern compost @750 kg/ha along with NPK fertilizer at 300, 200, and 250 kg/ha had significantly influenced the growth, development, and maximum (28.50 MT/ha) yield of tuber [16]. Similar results were reported by the earlier worker and the maximum yield (29.55 MT/ha) was obtained from the application of Northern Compost @750 kg/ha, Urea@300 kg/ha, TSP@200 kg/ha, and MOP@250 kg/ha [17].

In the present experiment, cowdung with mustard oil cake (T6) performed better considering standard grade tuber yield compared to other treatments in Kashimpur farm. Our results conform with previous workers. The maximum plant height (72.1 cm), number of stems per plant (4.15), number of tubers (8.35) per hill, and yield of tuber (22 MT/ha) were obtained when the potato was grown with cowdung plus mustard oil cake, N, P_2O_5 and K_2O compared to without fertilizer [18]. Similarly, the highest plant (71.2 cm), maximum number of shoots per plant (5.0), number of tubers per hill (9.0), the yield of tuber per hill (365g), tuber size (14.5 cm), potato yield (24.3 MT/ha) were found in cowdung plus mustard oil cake, N, P_2O_5, and K_2O compared to others treatment combinations [19]. Cowdung provided potato tuber yield increment of 38 - 82% [8]. The combination of organic matter with conventional farming exhibited its superiority in yield and yield contributing characteristics of potatoes [20]. In an earlier experiment, poultry manure-treated plants had the highest uptake of P, K, Mg, and S of both tuber and haulm, but N and Zn uptake was highest in the case of inorganic fertilizer plus poultry manure treatment. Calcium uptake was highest in cowdung in both cases of tuber and protein and starch contents were influenced by organic farming [21]. So, organic materials supplement in the soil improved the soil health status and long-term availability of nutrient elements resulting in the better yield and quality graded tuber of potatoes in our study.

5. Conclusion

In conclusion, the highest potato yield was found due to the application of both macro and micronutrients adding Mg in potato variety Courage whereas the combination of nutrients enhances the tuber yield in variety Asterix. The highest tuber yield per hill was obtained by applying northern organic fertilizer (NOF) in variety Asterix and courage by Chook Chook (CC) organic fertilizer. Treatments namely northern organic fertilizer (NOF) and cowdung with mustard oil cake (CMOC) performed better considering standard grade tuber yield (grade A and B) of both varieties Asterix and Courage compared to other treatments.

Abbreviations

NPKS, Nitrogen, Phosphorus, Potassium, and Sulfur; MT, Matric Ton; OM, or-

ganic matter, MoP, Murate of Potash; TSP, Triple Super Phosphate; NOF, Northern Organic Fertilizer; CC, Chook Chook; CMOC, Cowdung with Mustard Oil Cake; BADC, Bangladesh Agricultural Development Corporation; MMT, Million Metric Ton; FAO, Food and Agriculture Organization; BBS, Bangladesh Bureau of Statistics; TCRC, Tuber Crops Research Center; BARI, Bangladesh Agricultural Research Institute; NPK, Nitrogen Phosphorus Potassium; ha, Hectare; DAS, Days after sowing; g, gram; Kg, Kilogram; MOC, Mustard Oil Cake; RCBD, Completely Randomized Block Design; *p*, Probability; LSD, Least Significant Difference; pH, Negative logarithm of Hydrogen ion concentration; L, Litre.

Conflicts of Interest

The authors declared that there are no conflicts of interest about the publication of this paper.

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